

Appendix I Sample Scope of Work for Aerial Photography, Digital Orthophotography, and Digital Mapping

<<ORG CODE>>

(DATE)

<site/project name>

Architect-Engineer (A-E) Contract # << >>

I-1. Background

The U.S. Army Corps of Engineers (USACE), <<DISTRICT>>, is working with <<partner agency/customer>> on <<project>>. This project requires detailed mapping in digital and hardcopy formats. The mapping will include surface and subsurface features and digital orthophotographs. The mapping will support <<design, environmental monitoring, etc.>>.

For these applications, USACE requires large-scale, high-resolution data that are spatially accurate and correctly attributed. These data will be analyzed and manipulated using Geographic Information System/Computer-Aided Design and Drafting (GIS/CADD) software designed to handle large volumes of data. Additionally, USACE and <<partner>> will update the data as necessary to reflect current conditions at the project site.

I-2. General Requirements

a. Location of work. The project area is the entire <<site>> which comprises __ <<acres/hectares/square miles/square kilometers>>. The area is shown on the enclosed vicinity plan.

b. General statement of work. In general terms, the project shall consist of:

- Acquiring aerial photography and appropriate horizontal and vertical ground control.
- Developing digital orthophotographs.
- Producing digital geospatial data (i.e., GIS/CADD layers) as defined in this scope of work.
- Preparing geospatial metadata in compliance with Federal standards.

I-3. Detailed Requirements

Note that these requirements should be confirmed with the photogrammetry manual (EM 1110-1-1000).

The A-E shall provide all necessary services associated with obtaining and providing the aerial photography described.

a. Flight plan layout and flight line index. The A-E shall produce one flight plan and one flight line index for the photography. The flight plan requires flight lines oriented north-south. The flight plan shall reflect aerial coverage inclusive of the entire installation as described in General Requirements above.

b. Airborne Global Positioning System (GPS) survey techniques. To augment control previously established using conventional on-the-ground survey methods, while making the fly-over to obtain aerial photography, the A-E shall use airborne GPS surveying techniques to capture the ground coordinate for each frame of photographic coverage. Cross-tie flight lines shall be added as necessary to ensure an accurate aerial triangulation solution. Airborne GPS coordinate values shall reference the <<UTM Zone 18 WGS84 Geodetic Datum UTM in meters>>.

c. Fully Analytic Aerial Triangulation (FAAT) services. The A-E shall use FAAT techniques to extend and densify ground control for the aerial photography at both scales. The A-E shall develop a fully analytical block and bundle aerial triangulation solution for each scale of photography. All measurements shall be accomplished using a first-order analytical stereo plotting system. The results of the final bundle adjustment must support Digital Elevation Model development and digital orthophotography production that meets National Map Accuracy Standards. The results of the aerial triangulation adjustment must reference <<UTM Zone 18, WGS84 Geodetic Datum UTM in meters>>. The A-E shall prepare a report and coordinate listing describing the processes used and the accuracies that were achieved as well as a refined coordinate listing and plot of the control network for the photography before commencing Digital Terrain Model (DTM) development.

d. Aerial survey. The A-E shall obtain new aerial photography of the entire installation of <<Picatinny Arsenal>> during the fall after deciduous trees have dropped their foliage. Aerial photography shall be obtained with a forward overlap of 80 percent and an overlap between flight lines of 40 percent to ensure against potential difficulties with sun angles and to seam together a mosaic of the final photography. The aerial film shall be annotated at the moment of exposure using a GPS-controlled flight management and control system. Aerial photography shall be obtained in accordance with the following guidelines.

(1) *Film quality.* Only fresh, fine-grain, high-speed, dimensionally stable, and safety base aerial film emulsions shall be used. Standard safety procedures shall be followed for rolling unexposed film forward before beginning exposures. Appreciable image movement at the instant of exposure shall be prevented.

(2) *Flying conditions.* Aerial photography shall be obtained only during periods when the sun angle exceeds 30 percent; the project site is free of snow, clouds, or cloud shadows (clouds obscure no more than 5 percent of any frame); the project site is free of dust and haze; and rivers and/or streams are within their normal banks.

(3) *Aerial camera.* The A-E shall use a precision aerial camera with a single-lens of standard 6-inch focal length for obtaining all photography. The camera shall be equipped with a high-resolution, distortion-free lens and a between-the-lens shutter with variable speed. The aerial camera used shall be of equal or better quality to a Wild Model [RC-30]. The camera shall have been calibrated by the U.S. Geological Survey (USGS) within 3 years of award of this delivery order. As evidence, the A-E shall provide a current USGS calibration report that is less than 3 years old.

(4) *Aircraft flight operations and equipment.* The flight crew and camera operator shall have had a minimum of 400 hours experience in flying precise photogrammetric mapping missions. The camera shall be installed in a mounting that dampens the effects of aircraft vibration. Aircraft exhaust gases shall be vented away from camera opening.

e. Processing, handling, quality of products after survey.

(1) The A-E shall produce one set of stable base film diapositives (natural color) for the photography to be used for the analytical aerial triangulation adjustment and the DTM development process. Images seen on diapositives shall be clear and sharp in detail; of uniform density; have the proper degree of contrast for all

details to show clearly; and be free of clouds and cloud shadows, streaks, smoke, static marks, fog, and other blemishes that could render them unsuitable for intended uses.

(2) The A-E shall produce one set of contact prints for each overflight (one natural color and one false color infrared) separated into even and odd numbers. Contact prints shall be printed on semigloss paper. The even-numbered set shall be provided to the Government as confirmation of the aerial photographic coverage. The odd set shall be held by the A-E for development of the analytical aerial triangulation solution.

(3) Border information to be printed on the film and prints shall include the date of photography, flight line and exposure numbers, negative scale (as a ratio and in feet), and the project title and location. The camera panel of instruments should be clearly legible on all processed negatives. Failure of instrument illumination during a sortie shall be cause for rejection of the photography. All fiducial marks shall be clearly visible on every negative.

(4) *Film storage.* The A-E shall store all diapositives in his possession on winding spools in plastic or metal canisters, with at least 3 feet of clear film left on the end of each roll, in a temperature-controlled setting. Each canister shall be labeled for identification and possible future delivery to the Government.

f. Production of digital orthophotography.

(1) The A-E shall produce digital raster files of the aerial photographic frames required for digital orthophoto production. The A-E shall use a flatbed scanner with a geometric repeatability of 2 microns. The scanner must be capable of capturing 24-bit (3-color band) information in a single pass. All raw raster scans shall be produced directly from the original film. The A-E shall post-process the scans using image-dodging software to remove tone differences induced by sun angle, shadows, or other factors. The required scans shall be produced at an input resolution of 1,200 DPI (dots per inch) yielding a resolution of 1' per pixel for the natural color imagery. Prior to scanning, the A-E shall prepare a sample scan from the photography. The scan should reflect the resolution and file size of the completed digital orthophotos. The raw scans shall be provided in TIF format on a CD-ROM disk. Each CD-ROM shall contain an ASCII text file indicating identification information similar to that printed on borders of film and prints for identification. This file should include date of photography, flight line and exposure numbers (may need to be in summary form), negative scale (as a ratio and in feet), and the project title and location. Files shall be named so as to clearly distinguish the photography within this digital orthophoto from the other scale, as well as from any flown previously.

(2) The A-E shall develop DTM files for use in digital orthophoto production. DTM data shall be collected on a regular grid at a post spacing to be determined by the photogrammetrist that will accurately characterize the terrain. All data collection shall be accomplished using first-order analytical stereoplotters instruments. The DTM data shall be collected for each stereo model and merged into a single, project-wide dataset. This merged file shall be evaluated for accuracy and to insure that the dataset contains no spikes or zero elevation points. The data for each digital orthophoto shall be clipped out of these datasets.

(3) The A-E shall produce digital orthophotography in accordance with the following criteria: 24-bit natural color at a scale of 1"=100' with a pixel resolution of 1' per pixel. Each digital orthophoto shall cover an area measuring 3000' X 2000', yielding a completed file size of 108 MB per orthophoto. A total of xx tiles are required to cover the project area.

(4) The completed orthophotographs shall be provided to the Government in GeoTIFF format on CD-ROM. The accuracy of the differential rectification will be checked by measurement of all control points and/or pass points. The edge match of all orthophotographs shall also be checked interactively. No linear feature may be offset more than 10 pixels at either scale of orthophotography. The A-E shall produce a

mosaic of the natural-color orthophotography and re-sample the imagery to a resolution of 5 feet per pixel. The mosaic shall be processed to minimize tone and contrast differences between adjacent orthophotos. The completed mosaic shall be written to CD-ROM in GeoTIFF format.

g. Digital geospatial data.

(1) The A-E shall develop digital geospatial data for the features in Table I-1 below. The A-E shall capture these features using appropriate stereo compilation and photogrammetric procedures as defined in EM 1110-1-1000. The mapping shall meet National Map Accuracy Standards. That is, no feature shall be spatially displaced by more than 1/40th-inch of map scale. All data shall follow the Spatial Data Standard for Facilities, Infrastructure, and Environment (SDSFIE) version 2.x.

(2) The features listed in Table I-1 shall be developed for the project site. The data shall follow graphic and attribute standards defined in the most recent version of the SDSFIE.

(Note that Table I-1 is only a guide. When filling out a scope of work, users are required to evaluate their specific requirements and refine the specifications for each use of this sample.)

Table I-1 Selected Features for Project Sites	
	Features
Site boundary (if applicable)	Environmental, continued
Transportation	GW feasibility studies
Paved roads	Landfills
Unpaved roads and trails	Water table contours
Bridges	UST/AST locations
Railroad	Vegetation
Runways/helipads	Tree stands
Parking lots paved & unpaved	Individual landmark trees
Road centerline	Large hedgerows
Structures	Topography
Labs	Contours
Offices	Spot elevations
Schools and libraries	Geodetic Control
Housing	USGS Benchmarks
Warehouses	Utilities
Public building (fire/police stations, government offices)	Water
Water bodies	Sewer
Lakes	Electrical
Ponds	Telephone
Rivers	Cable
Streams	Natural gas
Drainage channels	Steam
Culverts	Other
Environmental	Golf Courses
Wetlands and marshes	Recreational fields
Sensitive habitat	Cemeteries
Wells	Power stations
Remediation/removal areas	Incinerators
CERCLA locations	Sewage treatment plants

(3) The final delivery format for the digital spatial data shall be <<Microstation DGN, Arc/INFO Coverages, Arc/INFO export .e00, Shapefiles, other file type>>.

(4) The final delivery format for the associated attribute data shall be <<Microsoft Access, ORACLE version <>, etc.>>. Attribute data and spatial data shall be properly related using a relate field of datalink in both datasets.

h. Geospatial metadata. In compliance with Executive Order 12906, all geospatial data for this project shall be documented with metadata. Metadata shall conform to Content Standards for Digital Geospatial Metadata (CSDGM) as defined by the Federal Geographic Data Committee (FGDC). One metadata file is required for each feature type, the DTM, and the digital orthophotography.

I-4. General Contract Requirements

a. Contract relationship. The contract relationship shall be directly between <<DISTRICT>> and the A-E. If the A-E receives requests for services beyond the scope of work from <<sponsor/partner>>, he shall notify USACE for direction before acting on the requests. All correspondence shall be sent through USACE.

b. Payments. Partial payments will be made monthly as the work progresses, with billings made monthly. Requests for payment will be submitted by the A-E on ENG Form 93 along with a narrative that describes the progress of work for that billing period. This narrative is the same as the status report listed in 4.5. ENG Form 93, and shall be submitted to the Project Manager for approval based on the services performed to date.

c. Government ownership. All data, reports, and material related to this project are the property of the Government and shall not be released by the A-E or his subconsultants without the prior written approval of USACE (and Partner).

d. Security clearance. No security clearances are required to perform this work. The A-E may be required to coordinate site visits for data collection with the installation where items and information of a sensitive nature may be compromised, or where historic sites are located in restricted areas.

I-5. Schedule of Submittals and Deliverables

The following items are required under this delivery order.

a. Planning submittal. Shall consist of the following, with one of each submitted to USACE and <<sponsor/partner>> no later than 5 days before the date of the overflight:

(1) *Flight line index in digital and hard copy form.* The A-E shall submit a hardcopy paper plot of each scale of photography and the digital files used to make the indices as Microstation design files on CD-ROM disk of the flight-line index.

(2) *USGS camera calibration report.*

b. Aerial photography. Shall consist of the following:

(1) All aerial photography shall be flown and completed before emergence of deciduous foliage in the spring.

(2) Airborne Global Positioning System (GPS) time-tagged, photocenter file shall be completed at the time of the overflight and submitted within 20 calendar days of the date of aerial photography.

(3) *Photographic submittal*. Shall consist of the following, to be submitted within 90 calendar days of the date of photography:

- One set of working diapositives for each scale of photography shall be submitted to the Government. Working diapositives shall be submitted within 90 days of the date of photography.
- One set of diapositives for use in aerotriangulation; to be stored by A-E in temperature-controlled setting as described above.
- One set of natural-color contact prints shall be divided into odd and even sets. The odd set shall be maintained by the A-E, and the even set shall be submitted within 90 days of the date of photography.

(1) *Digital submittal*. Shall include 24-bit raster scans for all frames required for digital orthophoto production, and shall be submitted on CD-ROM within 135 calendar days of the date of photography. Each CD-ROM and file shall be identified as described in section I-3f(1). Each submittal shall contain the following:

- Analytical aerotriangulation adjustment and report shall be completed and submitted within 135 calendar days of the date of aerial photography.
- DTM data files shall be collected and submitted within 135 calendar days of the date of aerial photography.
- Digital orthophotos in 24-bit, natural-color at a scale of 1"=MMM' with a resolution of X' per pixel, tile size 3000' X 2500' in GeoTIFF format on CD-ROM shall be submitted within 135 days of the date of photography.
- Digital mosaic of the natural-color orthophotos resampled to a resolution of 1' per pixel in GeoTIFF format on CD-ROM shall be submitted within 135 days of the date of photography.

(2) *Time extension*. The Government agrees to extend the delivery order submittal dates by 1 day for each day of delay due to Government review and approval of prior submittal.

I-6. Special Criteria and Instructions

Engineer Manual (EM) 1110-1-1000, "Photogrammetric Mapping," 31 March 1993;
American Society for Photogrammetry and Remote Sensing, 1990;
SDSFIE, Version 2.x

I-7. Government-Furnished Data

Vicinity Plan
TSC Website to acquire SDSFIE (<http://tsc.wes.army.mil>).

I-8. Points of Contact

a. <<Partner>>

b. USACE Project Manager: <<NAME>>

Department of the Army,

Commander, <<District>>

ATTN: <<CExxx-xx-xx>> (NAME)

<<ADDRESS>>

Telephone: <<xxx.xxx.xxxx>>

Fax: <<xxx.xxx.xxxx>>

E-Mail: xxxxx.xxxxxx@usace.army.mil